

Technical Paper

Effect of Heat Shock Treatment and Aloe Vera Coating to Chilling Injury Symptom in Tomato (*Lycopersicon esculantum* Mill.)

Pengaruh Perlakuan Heat Shock dan Pelapisan Aloe Vera pada Gejala Chilling Injury untuk Tomat (*Lycopersicon esculantum* Mill.)

Sutrisno¹, Y. Aris Purwanto² dan Olly S. Hutabarat³

Abstract

*This research was undertaken to determine the effect of length in heat shock and edible coating as pre-storage treatment to Chilling Injury (CI) symptom reflected by ion leakage induced and quality properties in tomato (*Lycopersicon esculantum* Mill.). Heat Shock Treatment (HST) was conducted at three different levels of length, which were, 20; 40 and 60 min. Edible coating was conducted using aloe vera gel. The result showed that HST and Aloe Vera Coating (AVC) were more effective to reduce CI symptom at lower chilling storage. Prolong exposure to heated water may delay climacteric peak. The length of heat shock, AVC treatment and low temperature storage significantly affected the tomato quality parameter but not significantly different for each treatment except weight loss. HST for 20 min at ambient temperature was significantly different to other treatment.*

Keywords: heat shock treatment, aloe vera coating, ion leakage, chilling injury, tomato

Abstrak

Penelitian ini dilakukan untuk mengetahui pengaruh lama perlakuan panas (*heat shock*) dan pelapisan bahan *edibel* sebagai perlakuan awal sebelum penyimpanan, terhadap gejala *chilling injury* (CI) yang diekspresikan sebagai terjadinya kebocoran ion (*ion leakage*) dan perubahan mutu pada tomat (*Lycopersicon esculantum* Mill.). *Heat Shock Treatment* (HST) dilakukan dengan pada 3 (tiga) tingkat lama perlakuan yang berbeda, yakni 20, 40 dan 60 menit. Pelapisan bahan *edibel* dilakukan dengan menggunakan gel lidah buaya. Hasil penelitian menunjukkan bahwa HST dan pelapisan lidah buaya (*Aloe Vera Coating*/AVC) lebih efektif dalam menurunkan gejala CI pada penyimpanan dengan suhu lebih rendah. Pencelupan pada air panas yang lebih lama dapat menunda pencapaian puncak klimakterik. Lamanya perlakuan panas, perlakuan AVC dan penyimpanan dengan suhu rendah secara signifikan berpengaruh terhadap parameter mutu tomat, akan tetapi tidak berbeda nyata jika perlakuan tersebut bersifat tunggal, kecuali pada parameter susut bobot. Perlakuan panas (HST) selama 20 menit pada suhu ruang berbeda secara signifikan dibandingkan perlakuan lainnya.

Kata Kunci : perlakuan panas (HST), pelapisan lidah buaya, *ion leakage*, *chilling injury*, tomat.

Diterima: 27 Oktober 2011; Disetujui: 02 Januari 2012

Introduction

It is well known that storage below room temperature and above freeze temperature may extend horticultural crops shelf life. Meanwhile, some physiological disorders were occurred in a number of horticultural crops due to its temperature condition. Failure to ripen, skin lesions and susceptibility to decay are typical symptoms of Chilling Injury (CI) (Lurie *et al.* 1997). Symptoms of

CI include increased membrane permeability and a resultant increase in leakage of cellular constituents (Murata 1990; Sharom *et al.* 1994 in Saltveit 2005).

The rate of ion leakage from excised tissue into an isotonic aqueous solution is a useful measure of the severity of chilling-induced increase in membrane permeability (King and Ludford 1983; Saltveit 2002 in Saltveit 2005). Ion leakage has been used as an indicator of damage to the plasma membrane and CI (Marangoni, Palma and Stanley 1996). The

¹ Department of Mechanical and Biosystem Engineering, Faculty of Agricultural Engineering and Technology, Bogor Agricultural University,

² Department of Mechanical and Biosystem Engineering, Faculty of Agricultural Engineering and Technology, Bogor Agricultural University, E-mail: kensutrisno@yahoo.com

³ Study Program of Postharvest Technology, Graduate School of Bogor Agricultural University

extent of injury depends on the environment to which the tissue was previously exposed, the type of tissue (e.g. meristematic, vegetative, root, stem, leaf and unripe or ripe fruit), temperature and length of exposure, and post-chilling conditions (Saltveit 2005). This phenomenon is especially important in postharvest handling and storage, as the use of low temperature is the most effective method to extend storage life of many products.

The application of a moderate heat treatment deeply modified postharvest metabolism which delay fruit ripening and decrease fruit decay (Vicente et al. 2006). A short-term treatment in water at 39–45°C appears to be an effective, inexpensive and environmentally safe method that reduces CI and decay (McDonald et al. 1999). In recent years, there have been several reports on the use of pre-storage heat treatments to reduce CI in horticultural crops exposed to low temperatures.

Aloe vera gel can be used as an edible coating to prolong quality and safety of fruits and vegetables. Maintaining sweet cherry quality using Aloe Vera Coating (AVC) was effective to reduce weight loss and lower respiration rate during postharvest storage (Romero et al. 2006). Polysaccharide edible coating has been widely applied as a means of permeable membrane to extend self life by reduce respiration rate. Aloe vera consists of polysaccharide functional component which enable to delay fresh horticulture deterioration by controlling water losses and prevent exchange of chemical component which dissolved in water.

Research data reported in this paper were undertaken to determine the effect of length in Heat Shock Treatment (HST) and AVC treatment to CI symptom reflected by ion leakage induced and quality properties in tomato (*Lycopersicon esculantum* Mill.).

Material and Methods

Plant Material

Mature green tomatoes were harvested from grower in Goalpara, Sukabumi in the morning and transported one day after harvested to the laboratory for four hours where the fruits were placed at ambient temperature. Upon arrival at the laboratory, fruits were threatened by HST and AVC.

Application of Heat Shock Treatments and Aloe Vera Coating

HST for mature green tomatoes was applied by soaking fruits into single hot water maintained at desired temperature ranges. Tomato was trimmed by (1 x 1 x 1) cm and soaked into 40 ml aqueous solution maintained at 42°C for 20 min, 40 min and 60 min.

AVC was performed by immersing for 5 min in a solution of aloe vera diluted 1:3 with distilled water

at 20°C and then being air-dried (Romero et al. 2006). Fruits were coated by edible aloe vera gel where fruits were immersed into 200 ppm chlorine solvent for 30 min.

Application of Low Storage

After exposed into 42°C and coated using aloe vera, in separate treatments, fruits were stored at 5°C and 10°C for 20 days. Fruits with non HST and AVC then stored at ambient temperature which were performed for control. Every 1 d storage, each sample was removed in to ambient temperature for 5 h to measure total electrical conductivity and quality properties. All the treatments were replicated by 3 times.

Measurement of Chilling Injury and Quality Properties

CI was determined by increasing of ion leakage during storage on chilled temperature which was reflected by total electrical conductivity. Periodically, the conductivity of the solution was measured every 20 min for 300 min at ambient temperature using electrical conductivity meter (D-24 HORIBA). In the end, sample was gently shaken using blender for 2 min to dissolve ion into aqueous solution to measure total electrical conductivity.

During storage, respiration rate; weight loss; Solid Soluble Content (SSC); firmness and color were measured. Fruit firmness was determined using rheometer CR-300, maximum load 2 kg, vertical pericarp surface 10 mm and pin diameter 5 mm. Weight loss was measured using digital scale to determine the initial and the final weight in each day. SSC was measured using ATAGO refractometer PR-201. Color was measured using chromameter.

Statistical Analysis

Statistical analysis was applied in order to see the significance level between treatments include HST and AVC; and also temperature storage to quality parameters include weight loss, firmness and SSC at the same maximum day of sample shelf life in each treatments. Each measurement was repeated three times. Variance analysis using Duncan Multiple Range Test (DMRT) with SAS was applied to perform statistical analysis.

Result and Discussion

Ion Leakage and Respiration Rate

Both treatments, HST and AVC, reflected lower ion leakage changes at storage of 5°C than at 10°C. Ion leakage from mature green tomatoes gradually decreased following storage at 5°C, but it increased drastically at 10°C storage (Fig. 1). On day of 19, there was significant different of total conductivity between storage at 5°C and 10°C. Thus showed that treatments using HST and AVC were more effective

to prevent CI on lower temperature storage, which was 5°C. Marangoni *et al.* (1996) reported that ion leakage increased drastically only after transfer to higher temperatures. Tomatoes chilled for 20 days at 5°C did not show increases in ion leakage. Damage to cells and tissues of tomato fruits occurred primarily during exposure to the chilling temperature, while development of injury symptoms mainly occurred upon removal from chilling to a warm, non-chilling temperature (Jing *et al.* 2009). Both storage at 5°C and 10°C, HST for 20 min produced the lowest total conductivity after removal. A short heat treatment on strawberry fruit quality and shelf-life could be partly due to the higher protection against oxidative molecules generated during fruit senescence or pathogen attack (Vicente *et al.* 2006).

In each treatment during storage, HST and AVC, greater temperature storage increased respiration rate and longer HST period delayed climacteric peak (Fig. 2). Climacteric peak on storage temperature was conditioned at 5°C on HST 20 min; 40 min and 60 min; AVC; control occurred at day 4; day 5; day 7; day 6; day 5 respectively. Where the storage conditioned at 10°C, climacteric peak occurred at day 3; day 2; day 4; day 5; day 3, respectively. Respiration rates represented by production rate of CO₂ of tomato treated at 5°C were considerably

lower than those treated by 10°C and ambient temperature. Heat water treatment increased respiration and ethylene evolution (McDonald *et al.* 1999).

Quality Properties

As mentioned above, statistical analysis was conducted at the same maximum day in each treatment, obtained at the 5th day. Table 1 represents DMRT value for each treatment. Treatments and temperature storage were significantly affected the weight loss percentage at day 5. HST for 20 min at ambient temperature was higher and significantly different from other treatment. Higher temperature increased percentage of weight loss (data not shown). Treatment with AVC showed no significantly different value.

At the early storage period, SSC started to increase then decreased (Fig. 3). Thus showed fruit climacteric phase character. Each treatment involved HST, AVC and low temperature storage significantly affected SSC at day 5 but there were no significantly different for each treatment. Similar to SSC, firmness was either showed that each treatment was significantly affected but there were no significantly different for each treatment. In the end of storage, fruits with unheated and uncoated

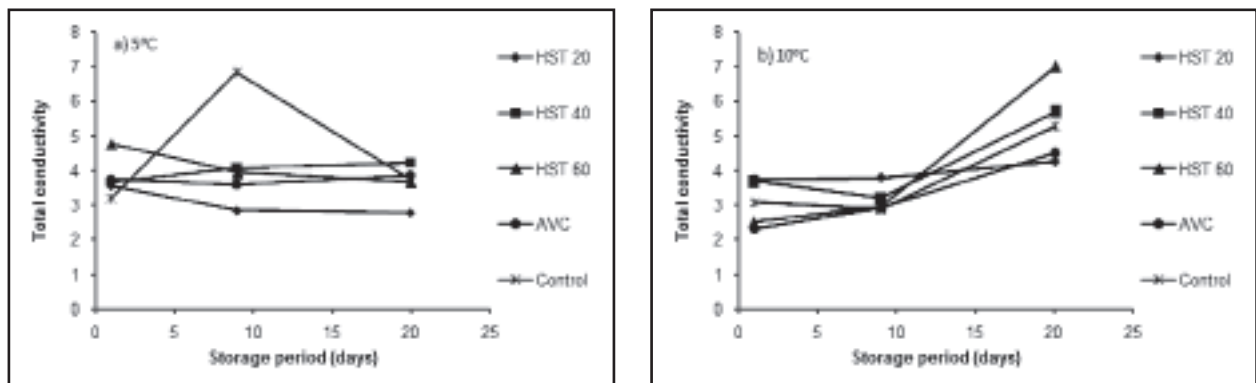


Fig 1. Total conductivity for heat shock treatment and aloe vera coating

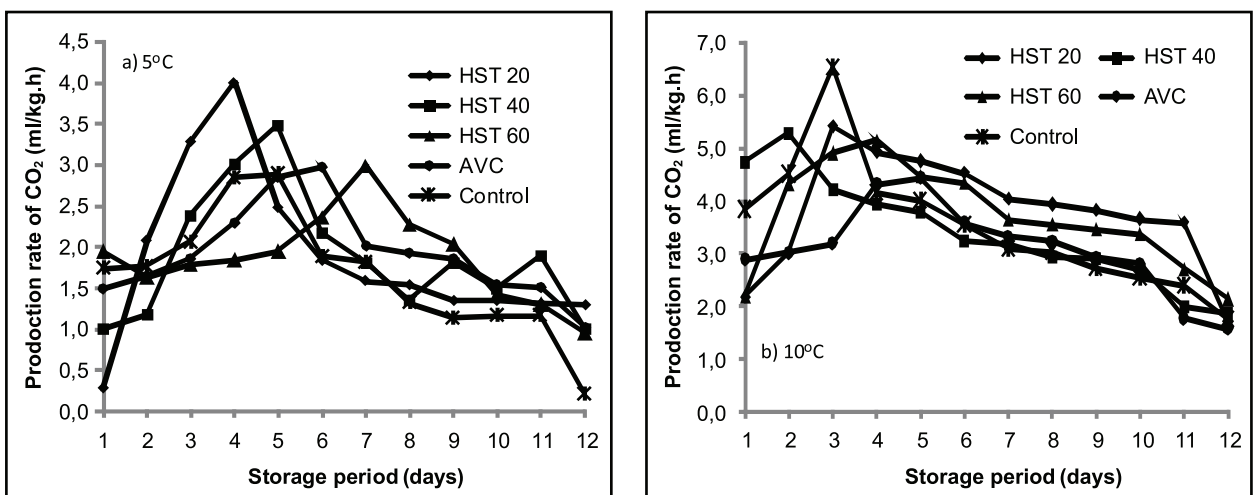


Fig 2. Respiration rate (ml.kg⁻¹.h⁻¹) of tomato under HST and AVC treatments before storage

Table 1. Duncan Multiple Range Test (DMRT) for each treatment

Treatments	Storage Temperature	Weight loss		Sf	Solid Soluble Content		Sf	Firmness		Sf
Heat Shock Treatment; t=20 min (HST20)										
	5	0.34	± 0.12	c	3.87	± 0.42	ab	0.21	± 0.01	e
	10	0.19	± 0.08	c	3.93	± 0.12	aa	0.40	± 0.18	bcde
	Ambient	1.11	± 0.25	a	3.27	± 0.23	bb	0.53	± 0.03	bcd
Heat Shock Treatment; t=40 min (HST40)										
	5	0.31	± 0.09	c	3.60	± 0.53	ab	0.51	± 0.13	bcd
	10	0.11	± 0.07	c	3.60	± 0.20	ab	0.57	± 0.19	bc
	Ambient	0.78	± 0.24	b	3.60	± 0.35	ab	0.34	± 0.03	cde
Heat Shock Treatment; t=60 min (HST60)										
	5	0.20	± 0.06	c	4.13	± 0.12	aa	0.43	± 0.02	bcde
	10	0.15	± 0.06	c	4.13	± 0.42	aa	0.50	± 0.17	bcd
	Ambient	0.78	± 0.18	b	3.60	± 0.35	ab	0.26	± 0.03	de
Aloe Vera Coating (AVC)										
	5	0.14	± 0.07	c	3.70	± 0.10	ab	0.63	± 0.38	ab
	10	0.11	± 0.08	c	3.62	± 0.49	ab	0.83	± 0.16	a
	Ambient	0.69	± 0.08	b	4.00	± 0.00	aa	0.36	± 0.01	bcde
Control										
	5	0.11	± 0.02	c	4.03	± 0.06	aa	0.52	± 0.02	bcd
	10	0.15	± 0.02	c	4.07	± 0.50	aa	0.41	± 0.11	bcde
	Ambient	0.75	± 0.06	b	4.00	± 0.00	aa	0.45	± 0.11	bcde

treatments had the lowest value for both SSC and firmness. CI is related with the damage of cell structure under chilling stress. Ultra structural membranes were well prevented from chilling damage by hot water treatment (Jing *et al.* 2009).

Lightness (L) for HST and AVC at low temperature increased by value of 58.15 to 63.38, while at ambient temperature decreased by value of 64.07 to 58.76. At low temperature, L value measured for each HST 20 min; 40 min; 60 min, AVC and control were 58.84 to 62.92 (5°C) and 58.26 to 63.38 (10°C); 61.43 to 61.19 (5°C) and 60.78 to 61.52 (10°C); 59.11 to 61.64 (5°C) and 61.74 to 62.01 (10°C); 60.23 to 60.91 (5°C) and 63.05 to 62.28 (10°C) respectively. In the early storage period, a* value increased raised to red while b* value decreased raised to dark yellow.

Some symptoms such as excessive water loss and skin lesion can develop during prolonged storage at chilling temperatures (Jing *et al.* 2009). The mechanisms by which pre-storage heat treatment reduces CI are still not very clear. Protective treatments such as temperature conditioning and heat shocks that are applied before chilling are thought to make tissue more resistant to the physiological damage that occurs during chilling. Heat treatment induces the synthesis of heat-shock protein, which is thought to act as chaperones that could be responsible for protein folding, assembly, translocation and degradation in many normal cellular processes, as well as assisting in protein refolding under stress conditions (Wang *et al.* 2004 in Jing *et al.* 2009).

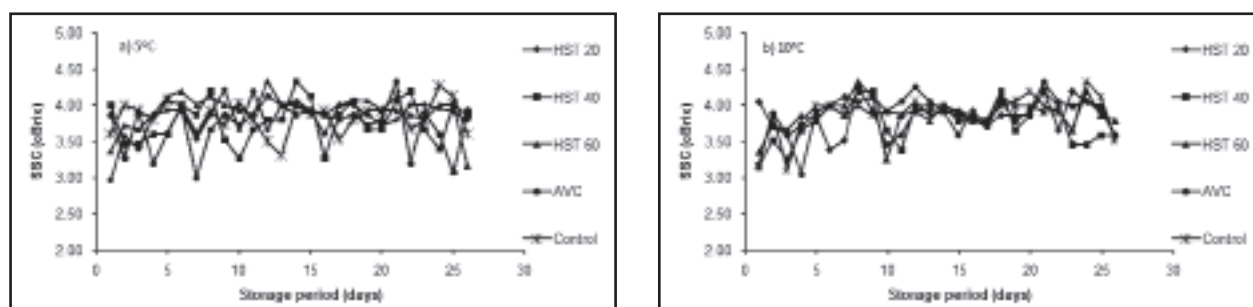


Fig 3. Solid Soluble Content (°Brix) changes during storage under treatments

Conclusion

Hot water treatment and aloe vera coating were more effective to reduce chilling injury symptom at lower chilling storage. Prolong exposure to heated water may delay climacteric peak. Extended period of heat shock treatment; aloe vera coating and low temperature storage significantly affected the tomato quality parameter but not significantly different for each treatment except weight loss. Heat shock treatment for 20 min at ambient temperature was significantly different to other treatment.

References

- Baloch, M.S., T.Marimoto, and K.Hatou. 2006. Postharvest heat stress application to reduce water loss in tomato during storage. *Agricultural Engineering International: the CIGR Ejournal*. VIII: 1-13.
- Jing, Y., F.Mao-run, Z.Yu-ying, and M.Lin-chun. 2009. Reduction of chilling injury and ultrastructural damage in cherry tomato fruits after hot water treatment. *Agricultural Sciences in China*. 8(3): 304-310.
- Lurie, S., M.Laamim, Z.Lapsker, and E.Fallik. 1997. Heat treatments to decrease chilling injury in tomato fruit: Effect of lipids, pericarp lesions and fungal growth. *Physiological Plantarum*. 100: 297-302.
- Marangoni, A.G., T.Palma, and D.W.Stanley. 1996. Review: Membrane effects in postharvest physiology. *Postharvest Biology and Technology*. 7: 193-217.
- McDonald, R.E., T.G.McCollum, and E.A.Baldwin. 1999. Temperature of water heat treatments influences tomato fruit quality following low temperature storage. *Postharvest Biology and Technology*. 16: 147-155.
- Romero, D.M, N.Alburquerque, J.M.Valverde, F.Guillen, D.Valero, and M.Serrano. 2006. Postharvest sweet cheery quality and safety maintenance by Aloe vera treatment: A new edible coating. *Postharvest Biology and Technology*. 39: 93-100.
- Saltveit, M.E. 2005. Influence of heat shock on the kinetics of chilling-induced ion leakage from tomato pericarp discs. *Postharvest Biology and Technology*. 36: 87-92.
- Vicente, A.R, G.A. Martinez, A.R. Chaves, and P.M. Civello. 2006. Effect of heat treatment on strawberry fruit damage and oxidative metabolism during storage. *Postharvest Biology and Technology*. 40: 116-122.